printed in heavier type. Since the publication of this monograph by Michaelsen one new genus (Hæmonais) has been founded by Bretscher, while Michaelsen (:03) has proposed the name Vejdovskyella for Bohemilla, the latter being preoccupied.

FAMILY NAIDIDAE

1791. *Nais* [ex Ord. Mollusca, e Class. Vermes] (part) Gmelin, *Syst. Nat.*, vol. 6, p. 3120.

1895. *Naidomorpha* (e Group *Microdrili*) Beddard, *Monogr. Olig.*, p. 275.

1900. *Naididæ* Michaelsen, *Monogr. Olig.*, *Das Tierreich*, Lief. 10, p. 16.

1903. *Naididæ* Michaelsen, *Die geogr. Verbreit. d. Olig.*, p. 41.

1905. *Naididæ* Michaelsen, "Zur Kenntnis d. Naididen," *Zoölogica*, vol. 18, p. 350.

Setæ aggregated together in 2 or 4 bundles on a segment. Dorsal bundles composed of capilliform, short needle-like, or sigmoid (the latter biuncinate) setæ; dorsal bundles often absent; ventral bundles composed of sigmoid biuncinate setæ. Dissepiments well developed. Brain, commissure, and ventral nerve-cord well developed, distinct from the hypodermis. Esophagus without muscular stomach. Nephridia large, occasionally entirely absent. Testes in segment 5 or 7 (rarely in segments 8 and 9). Ovaries in segments 6 and 7 (rarely in segment 10). Spermatheca in segment 5 or 7. Reproduction normally asexual by budding. Length of specimens varies from 1 to 50 mm.; usually from 2 to 10 mm.

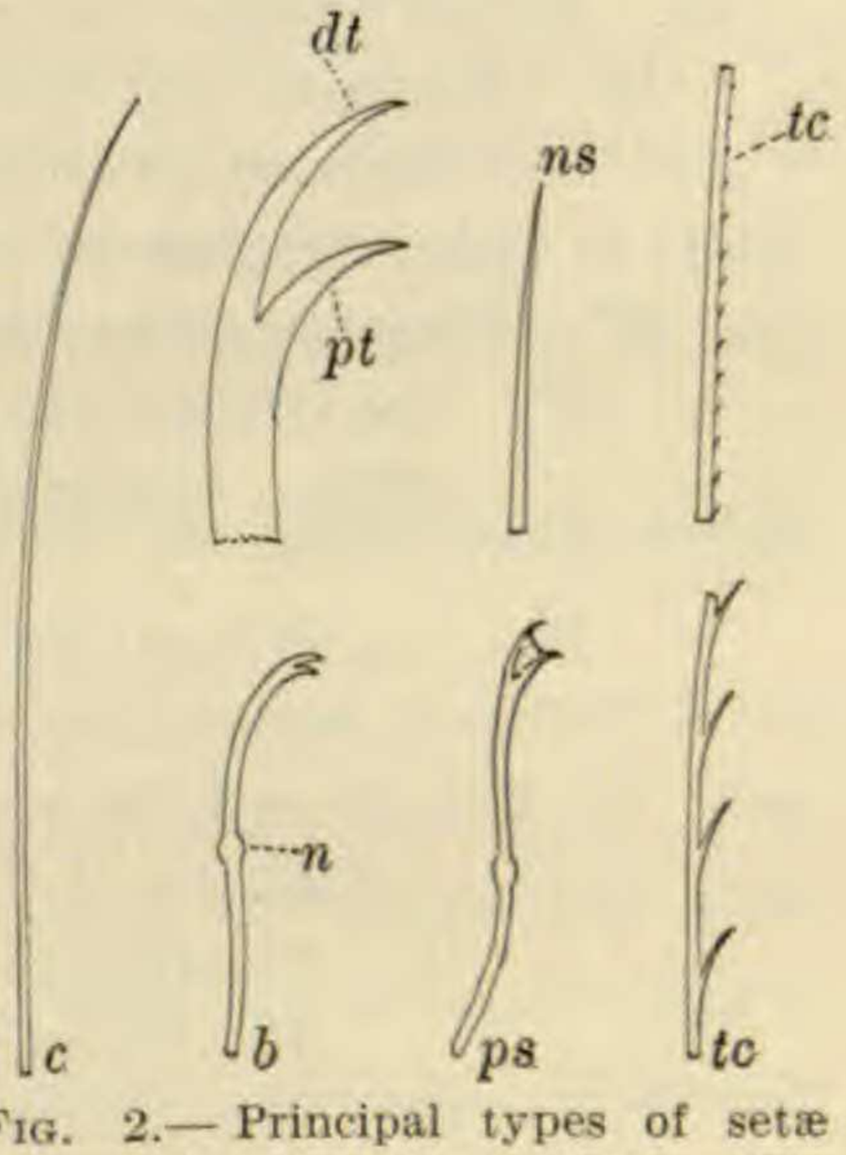

FIG. 2.—Principal types of setæ occurring in the Naididæ. For abbreviations see Fig. 1.

Usually in fresh water, rarely in saline waters. One (Amphichæta) marine. Cosmopolitan; fifteen genera.

Synoptic Table for Separation of Described Genera

(Genera occurring in North America printed in heavy type)

A¹. Capilliform setæ absent.
B¹. Dorsal bundles of setæ absent.
C¹. Ventral bundles of setæ on all segments beginning with the second. Third segment not longer than remaining segments *Schmardella.*
C². Ventral bundles of setæ absent on segment 3–5. Segment 3 extremely long . . . . . **Chætogaster.**
B². 2 dorsal and 2 ventral bundles of setæ on a segment.
C¹. Segment 3 much longer than remaining segments. Length (of described species) not exceeding 2 mm. . *Amphichæta.*
C². Segment 3 not longer than remaining segments. Length (of described species) equal to or exceeding 5 mm.
D¹. All setæ of dorsal bundle biuncinate . . . . *Paranais.*
D². Some of the setae of dorsal bundle not biuncinate **Ophidonais.**
A². Capilliform setæ present in the dorsal bundle.
B¹. Dorsal bundle of setæ beginning on segment 2, 5, or 6.
C¹. Dorsal bundle of setæ beginning on segment 5 or 6.
D¹. Posterior end developed into a tubular respiratory process containing paired gills. Usually living in tubes composed of plant fragments, etc. . . . . **Dero.**
D². Posterior end without respiratory processes.
E¹. Capilliform setæ of dorsal bundle with a series of prominent teeth. Dorsal bundle beginning on segment 5 *Vejdovskyella.*[1]
E². Capilliform setæ without teeth. Dorsal bundle beginning on segment 6.
F¹. Length of capilliform setæ equal to at least twice the diameter of the body.
G¹. Capilliform setæ on all segments beginning with 6. Prostomium rounded . . . . . *Macrochætina.*
G². Capilliform setæ only on one (6) or a few (6, 7, 8) segments.
H¹. Capilliform setæ on segments 6, 7, and 8. Prostomium developed into a tentacular process *Ripistes.*
H². Capilliform setæ only on segment 6. Prostomium not developed into a tentacular process **Slavina.**
F². Length of capilliform setæ shorter or rarely longer than diameter of body.

[1] For Bohemilla, previously used as the generic name for a group of Trilobites by Barrande, (Michaelsen. : 03).

G¹. Prostomium developed into a tentacular process **Stylaria.**

G². Prostomium rounded . . . . . **Nais.**

C². Dorsal bundle of setæ beginning on segment 2.

D¹. Anterior capilliform setæ partly covered by filamentous gills *Branchiodrilus.*

D². No filamentous gills present.

E¹. Dorsal bundle usually composed entirely of capilliform setæ. Prostomium developed into a long tentacular process . . . . . **Pristina.**

E². Dorsal bundle composed in part of biuncinate or of short needle-like setæ. Prostomium rounded or with a short tentacular process . . . . . **Naidium.**

B². Dorsal bundle of setæ beginning on segment 12–20 *Hæmonais.*

Genus CHAETOGASTER K. Baer, 1827

Prostomium rudimentary, coalesced with segment 1; 2 ventral bundles of setæ on a segment, these absent on segments 1 and 3–5. Setæ uncinate. Pharynx large and wide. Esophagus small, not longer than pharynx; 1 pair of transverse vessels connects the dorsal and the ventral vessels. Longitudinal commissures of ventral nerve-cord more or less distinct in anterior part of body. Testes in segment 5, ovaries in segment 6, spermathecæ in segment 5.

In fresh water, free-living or parasitic on fresh-water snails. Middle and south Europe, North America.

Five species are recognized by Michaelsen and to these must be added *C. pellucidus.* Three species of Chætogaster (*C. diastrophus*, *C. diaphanus*, and *C. limnæi*) have been reported from North America, while Leidy ('52), described *C. gulosus*, so incompletely, however, that it cannot be recognized, although undoubtedly referable to the genus Chætogaster.

The following table will serve to separate all the species known at the present time: —

A¹. Prostomium distinct, usually with a pore on anterior margin *C. diastrophus.*
(Europe, N. America.)

A². Prostomium indistinct.

B¹. Length of individuals not exceeding 5 mm.

C¹. Esophagus as long as pharynx.

D¹. Blood vessels of pharyngeal region well developed *C. langi*. (Europe, N. America.)

D². Blood vessels of pharyngeal region absent or only slightly developed . . . . . *C. crystallinus*. (Europe.)

C². Esophagus shorter than pharynx, indistinct.

D¹. Ventral setæ 8 to 12 in bundle, 1st postesophageal dilation of intestine covered with anastomosing network of blood vessels . . . . . *C. limnæi*. (Europe, N. America.)

D². Ventral setæ 6–7 in bundle, 1st postesophageal dilation of intestine surrounded by 12 or more pairs of non-anastomosing transverse blood vessels . . . . . *C. pellucidus*. (N. America.)

B². Length of individuals 10–15 mm. . . . . *C. diaphanus*.

Chætogaster langi Bretscher

C. langi Bretscher, *Rev. Suisse Zoöl.*, vol. 3, p. 512, fig. 1, 1896; Michaelsen, *Das Tierreich, Oligochaeta*, Berlin, p. 21, 1900.

Living specimens transparent. Prostomium blunt, indistinct. Setæ unequally bifid at distal end, 4 in a bundle. Esophagus long. Ventral ganglia glandular in form. Circulatory system with normal development in the pharyngeal region, 1 pair of transverse vessels (not developed as "hearts") in esophageal segment. Length 1–2 mm.

Between filaments of algæ in swampy places, etc.

One specimen (Fig. 3) referable to this species was obtained early in July. There were several minor characteristics not wholly in agreement with the description of *C. langi*, but in the absence of more material it must be placed here.

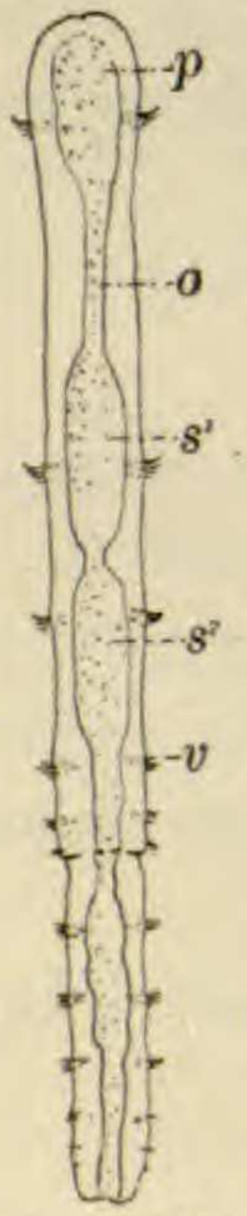

FIG. 3. — *Chætogaster langi* Bretscher (x25). For abbreviations see Fig. 1.

Chaetogaster pellucidus n. sp.

Transparent. Prostomium indistinct. Eyes absent. Dorsal setæ absent, ventral setæ 6–7 in a bundle, biuncinate, with teeth unequal. Esophagus short, postesophageal dilation (first stomach) sur-

rounded by 12 or more pairs of non-anastomosing transverse blood vessels. Length 1.5 mm. Number of segments in an individual from 9 to 11. Budding in all specimens observed.

Sandusky Bay, Lake Erie.

A considerable number of specimens of this small Chætogaster were observed in cultures of aquatic plants during July and August, and a number were stained and mounted and are now in the

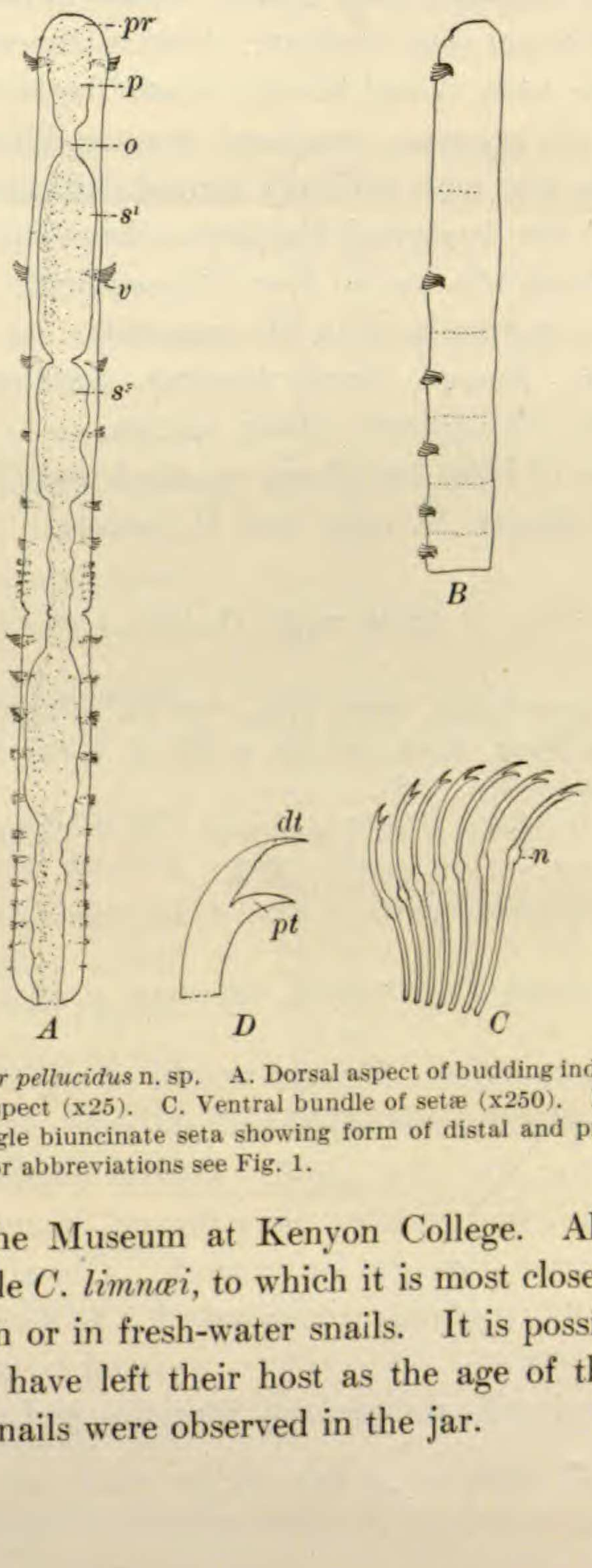

FIG. 4.— *Chætogaster pellucidus* n. sp. A. Dorsal aspect of budding individual (x25). B. Lateral aspect (x25). C. Ventral bundle of setæ (x250). D. Distal portion of a single biuncinate seta showing form of distal and proximal tooth (x1000). For abbreviations see Fig. 1.

collection of the Museum at Kenyon College. All found were free living, while *C. limnæi*, to which it is most closely allied, normally occurs on or in fresh-water snails. It is possible, however, that they may have left their host as the age of the culture increased. No snails were observed in the jar.

Furthermore, Vejdovsky ('84) figures the first postesophageal dilation of *C. limnæi* as being covered with an anastomosing network of blood vessels, while in *C. pellucidus* they are plainly non-anastomosing.

Genus DERO Oken, 1815

Prostomium rounded, eyes absent. Setæ in four bundles on a segment. Ventral setæ uncinate, those of the segments 2 to 5 longer than the rest; dorsal bundle usually beginning on the 6th rarely on the 5th segment, composed of a capilliform and one or two needle-like setæ with variously formed distal ends. Posterior end developed into branchial filaments. Intestine with stomach. Blood red. Nephridia paired from 6th segment. Testes in 5th, ovaries in 6th, spermathecæ in 5th segments.

Fresh water. Europe, North America, Antilles, tropical East Africa, Tonkin, Philippines; fifteen species.

Four species of Dero have been reported from North America: *D. obtusa*, *D. limosa*, *D. vaga*, and *D. furcata*.

Dero vaga (Leidy)

Aulophorus vagus Leidy, *Amer. Nat.*, vol. 14, p. 423, figs. 3, 4, 1880; Reighard, *Proc. Amer. Acad.*, vol. 20, p. 88, pl. 1, figs. 1–10; pl. 2, figs. 11–20; pl. 3, figs. 21–31, 1885.

Dero vaga L. Vaillant, *Hist. Nat. Annel.*, vol. 3, p. 383, 1890; Stieren, *Sitzb. Ges. Dorpat*, vol. 10, p. 107, 1893.

D. furcata Bousfield (part), *Journ. Linn. Soc. London*, vol. 20, p. 105, 1887.

D. vaga Michaelsen, *Das Tierreich, Oligochæta*, p. 29, 1900.

Prostomium rounded. Ventral bundle of segments 2 to 5 with 8 to 14 long slightly curved, biuncinate setæ, with upper somewhat longer than the lower tooth. Ventral bundles of remaining segments with 4 to 7 shorter, more curved, biuncinate setæ with the upper shorter than the lower tooth. Dorsal bundle of setæ beginning on 6th segment; composed of 1 to 3 capilliform and 1 to 3 palmate setæ.

Posterior end with rudimentary branchia and two long finger-

like processes. Three pairs of hearts in segments 8, 9, and 10. Brain wider than long. Length 8 mm. or more; number of segments in an individual 24 to 35.

In slime of ditches, etc., among fresh-water plants. Massachusetts (Cambridge), Pennsylvania (Philadelphia), Illinois, Ohio (Cedar Point), and Trinidad, West Indies.

This species was extremely common at Cedar Point, particularly among cultures containing *Riccia fluitans*, the thallus of which together with statoblasts of Bryozoa, etc., it uses in the building of a protective tube by means of a viscid secretion from the body. When walking around with its tube it bears a striking resemblance to a minute caddis-fly larva.

Genus STYLARIA Lamarck, 1816

Prostomium developed into a tentacular process. Ventral bundles composed of biuncinate setæ; dorsal bundle composed of capilliform setæ, beginning on 6th segment. Testes in 5th, ovaries in 6th, spermathecæ in 5th segment.

Fresh water. Europe, North America; one species.

Stylaria lacustris (Linné)

Nereis lacustris Linné, *Syst. Nat.*, ed. 10, p. 654, 1758; ed. 12, vol. 2, p. 1085, 1767.

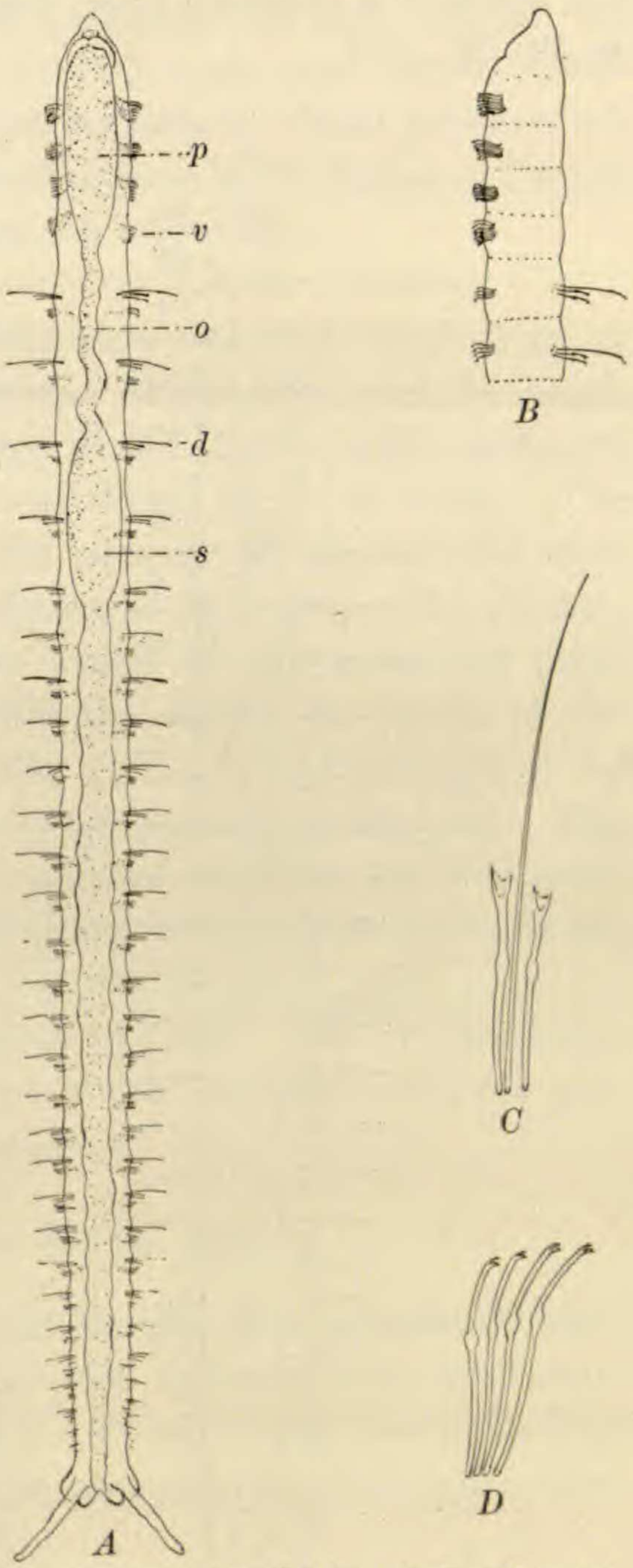

FIG. 5.— *Dero vaga* Leidy. A. Dorsal aspect (x25). B. Lateral aspect, first six segments (x25). C. Dorsal bundle of setæ (x250). D. Ventral bundle of setæ, 6th segment (x 250). For abbreviations see Fig. 1.

Stylaria lacustris Johnston, *Cat. Brit. Non-paras. Worms*, p. 70, 1865; Vejdovsky, *Syst. Morphol. Olig.*, p. 30, pl. 3, fig. 27; pl. 4, figs. 1–24, 26–31, 1884.

Nais lacustris Beddard, *Monogr. Olig.*, p. 284, 1895; Michaelsen, *Das Tierreich, Oligochæta*, p. 33, 1900.

S. paludosa, S. fossularis Leidy, *Proc. Acad. Nat. Sci. Phila.*, vol. 5, pp. 286, 287, 1852.

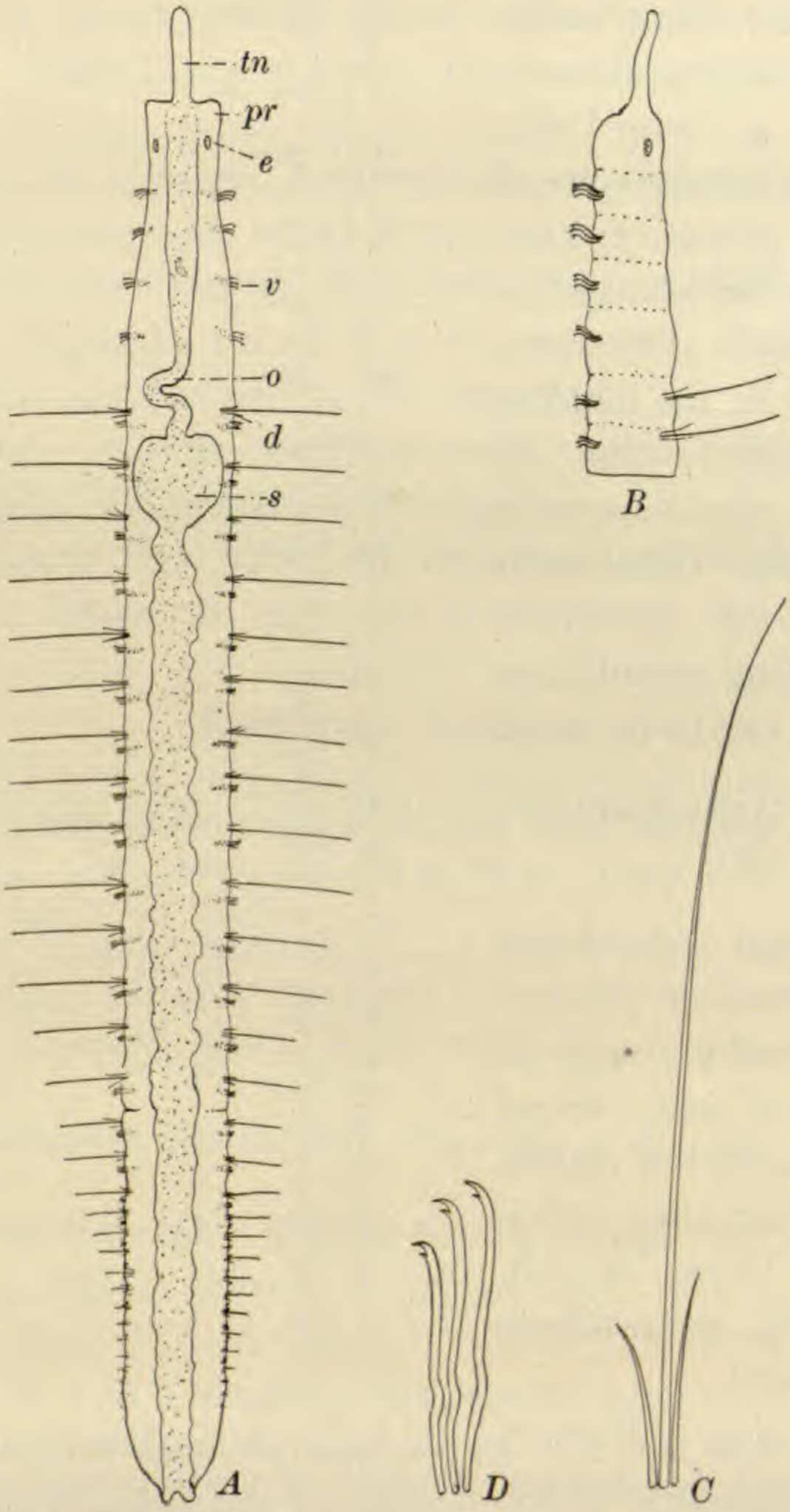

FIG. 6.— *Stylaria lacustris* (Linné). A. Dorsal aspect (x25). B. Lateral aspect, first 6 segments (x25). C. Dorsal bundle of setæ of 6th segment (x250). D. Ventral bundle of setæ, 4th segment (x250). For abbreviations see Fig. 1.

S. phyladelphiana, S. scotica Czerniavsky, *Bull. Soc. Imp. Nat. Moscou,* vol. 55, no. 4, p. 309, 1880.

Prostomium developed into a long tentacular process. Eyes usually present. Distal teeth of ventral setæ unequal. Dorsal setæ capilliform with 1 long and 1 to 2 short in each bundle. All long setæ of each bundle approximately of the same length. Clitellum in sexually mature forms on segment 6. Male pores on 6th segment. Sperm duct in 5th, spermathecæ in 5th segment. Length 10 to 15 mm. Number of segments about 25.

Europe, North America (Pennsylvania, Ohio, Illinois).

A large number of specimens were observed which must at present be referred to this species. Michaelsen notes the length of *N. lacustris* as varying between 10 and 15 mm., while the length of those found at Cedar Point was always from 4 to 5 mm. The teeth of the ventral setæ are also considerably shorter and more obtuse than illustrated in the figures of Vedjovsky ('84), Tauber, and others. Furthermore, the length of the tentacular process in those forms observed, did not exceed the length of the long capilliform setæ while Müller (1774) notes the length of the tentacular process as equivalent to ten segments of the body. The synonymy of *S. lacustris* is in a confused condition, and it is possible that careful study will establish one or more new species in the genus.

The imperfect descriptions given by Leidy ('52b) to the species described by him as *S. paludosa* and *S. fossularis*, will not permit their separation from *S. lacustris.*

Genus Nais Müller, 1774

Prostomium rounded. Ventral bundle with biuncinate setæ. Dorsal bundle beginning on the 6th segment with capilliform and variously pointed short setæ. Testes in 5th, ovaries in 6th, spermathecæ in 5th segments (in species where sex organs have been observed).

In fresh water. Europe, North America, South America, and East India; ten species.

The genus Nais furnishes one of the most difficult problems for the systematist attempting to define the limits of species among

the Naididæ. The following table, however, embodies the results of systematic work so far as they are known and comprises all species described up to the present time.

A[1]. Setæ of ventral bundle of segments 8 to 10 neither thicker than those of other segments nor modified by possessing blunt tips with rudimentary lower tooth.

B[1]. Eyes present.

C[1]. Ventral setæ of segments 2 to 5 much longer than those of succeeding segments. Dorsal setæ capilliform, 4 to 8 in bundle *N. obtusa.*
(Europe, S. Siberia.)

C[2]. Ventral setæ of segments 2 to 5 not decidedly longer than those of succeeding segments.

D[1]. Transverse blood vessels simple.

E[1]. Ventral setæ of segments 2 to 5 unequally bifid at tip. Length 1 to 1.5 mm. . . . . *N. elinguis.*
(Europe, N. America, S. America.)

E[2]. Ventral setæ of segments 2 to 5 equally bifid at tip.

F[1]. Number of segments in an individual approximately 10 (9 to 10), 6 to 8 ventral setæ in a bundle. Length of specimen 1.5 mm. . . . . *N. parvula.*
(N. America.)

F[2]. Number of segments in an individual usually 20 (18 to 22), 4 ventral setæ in a bundle. Length of specimens at least 2 mm.

G[1]. Dorsal bundles composed of 1 long capilliform and 2 short needle-like setæ. Eyes dumbbell-like in form *N. tortuosa.*
(N. America.)

G[2]. Dorsal bundle composed of 1 long capilliform and 1 short biuncinate seta. Eyes oval, not dumbbell-like in form. Length 3.5 mm. . . . . *N. parviseta.*
(N. America.)

D[2]. Transverse blood vessels of segments 2 to 5 forked. Dorsal bundle with biuncinate setæ. . . . . *N. heterochæta.*
(England.)

B[2]. Eyes absent.

C[1]. Proximal tooth of dorsal biuncinate setæ not longer than the distal tooth.

D[1]. Ventral bundle composed of 3 to 4 setæ. Length of individuals 3 to 3.5 mm. Colorless . . . *N. tenuidentis.*

D[2]. Ventral bundle composed of 6 to 8 setæ. Length 6 to 8 mm. Color reddish . . . . . *N. josinæ.*
(Europe, N. America.)

C². Proximal tooth of dorsal biuncinate setæ twice the length and twice the thickness of the distal tooth . . *N. paraguayensis.* (S. America.)

A². Setæ of ventral bundle of segments 8 to 10 much thicker than those of other segments, 1 to 2 in number, tips blunt, proximal tooth rudimentary . . . . . *N. bretscheri.* (Europe.)

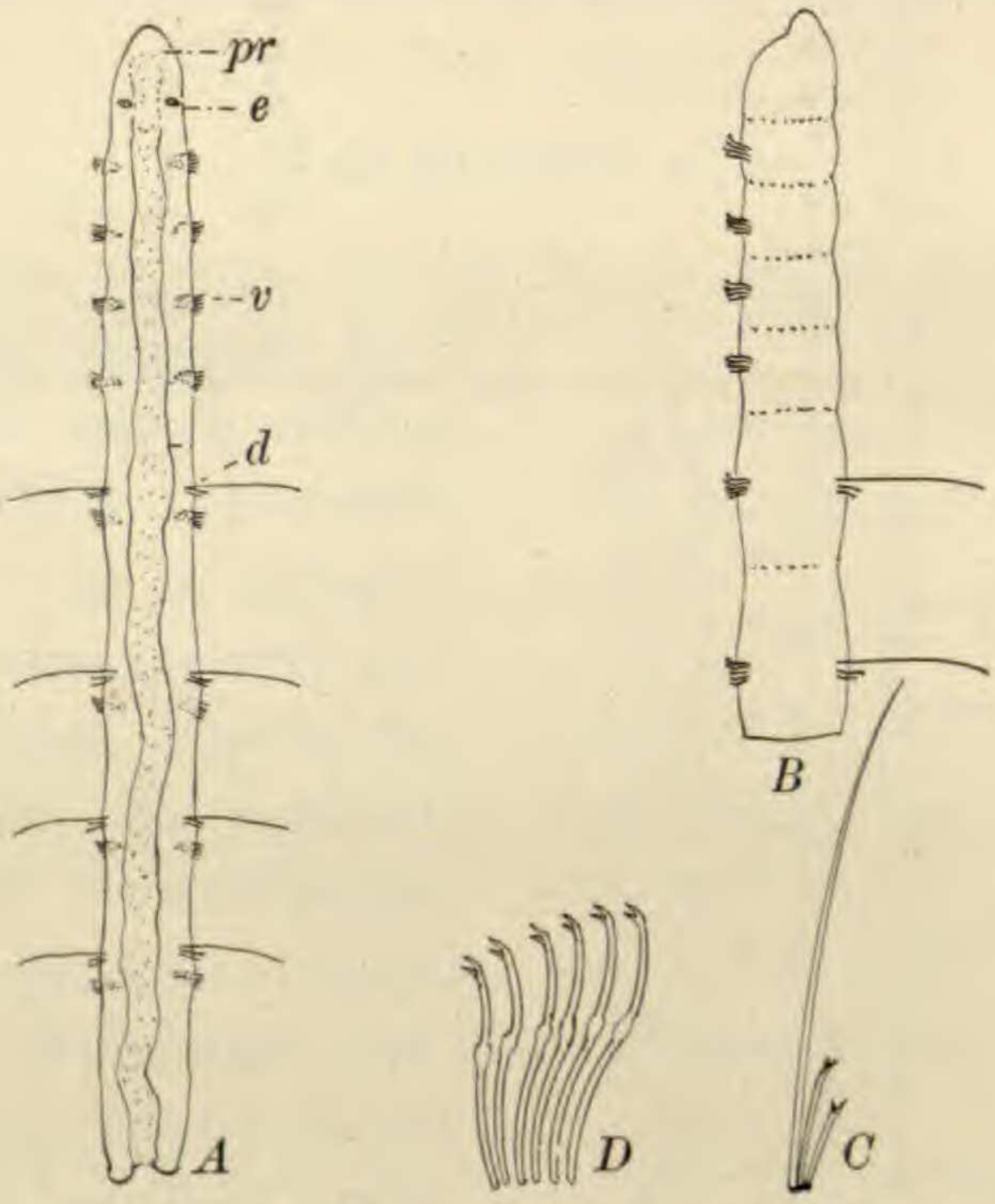

FIG. 7.— *Nais parvula* n. sp. A. Dorsal aspect (x50). B. Lateral aspect, first six segments (x50). C. Dorsal bundle of setæ of 6th segment (x250). D. Ventral bundle of setæ, 6th segment (x250). For abbreviations see Fig. 1.

Nais parvula n. sp.

Prostomium blunt, rounded. Eyes present. Digestive tract not differentiated into esophagus and stomach. Dorsal bundle beginning on segment 6, composed of 1 capilliform, subequal to diameter of body, and 2 short biuncinate setæ. Ventral bundle consisting of 6 to 7 biuncinate setæ with teeth equal. Length 1.2 mm. Number of segments in an individual 9 to 10.

Cedar Point, Sandusky, Ohio.

Several examples of this extremely small Nais were found in the slime accumulating at the bottom of jars containing roots of various aquatic plants obtained from Sandusky Bay. It is chiefly

remarkable by reason of its small size, and the limited number of segments composing the body. At first it seemed probable that it was an immature form but evidence to the contrary was given by budding in several specimens.

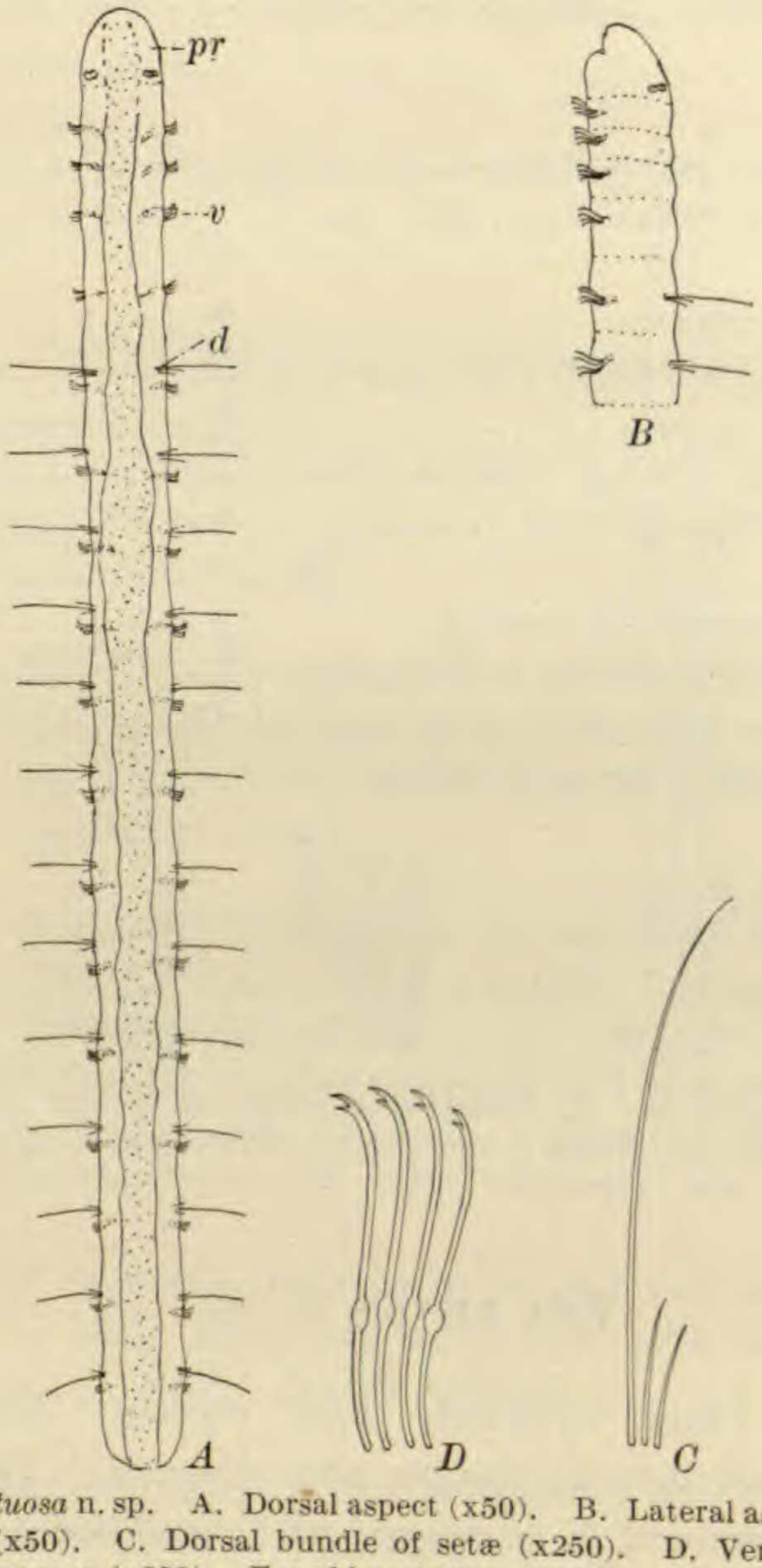

FIG. 8.— *Nais tortuosa* n. sp. A. Dorsal aspect (x50). B. Lateral aspect of first six segments (x50). C. Dorsal bundle of setæ (x250). D. Ventral bundle of setæ, 2d segment (x250). For abbreviations see Fig. 1.

Nais tortuosa n. sp.

Prostomium blunt, rounded. Eyes present slightly dumbbell-shaped. Digestive tract not differentiated into esophagus nor stomach. Dorsal bundle beginning on 6th segment, composed of 1 long capilliform (180 μ) and 2 short (50 μ) needle-like setæ. Ven-

tral bundle consisting of 4 biuncinate setæ (110 μ) with subequal teeth. Length 2.2 mm. Number of segments in an individual 18.

Cedar Point, Sandusky, Ohio.

Two specimens belonging to this species were noted. Budding was not observed. Several Peritrichous ciliates (*Rhabdostyla* sp., length 50 μ, diameter 19 μ) were observed fixed to the anterior end of one of the individuals, the peduncle being less than 2 μ in length.

Nais parviseta n. sp.

Prostomium narrow, slightly acute. Eyes present, round or slightly oval. Digestive tract differentiated into a distinct pharynx which gradually merges into an esophagus. Stomach dilation scarcely perceptible. Dorsal bundle beginning on the 6th segment, composed of 1 capilliform, subequal to diameter of body, and 1 short biuncinate seta, possessing equally developed teeth and an indistinct nodulus. Ventral bundle composed of 3 to 4 biuncinate setæ, with lower tooth considerably larger than the upper tooth. Length 3.5 mm. Number of segments in an individual 19 to 20.

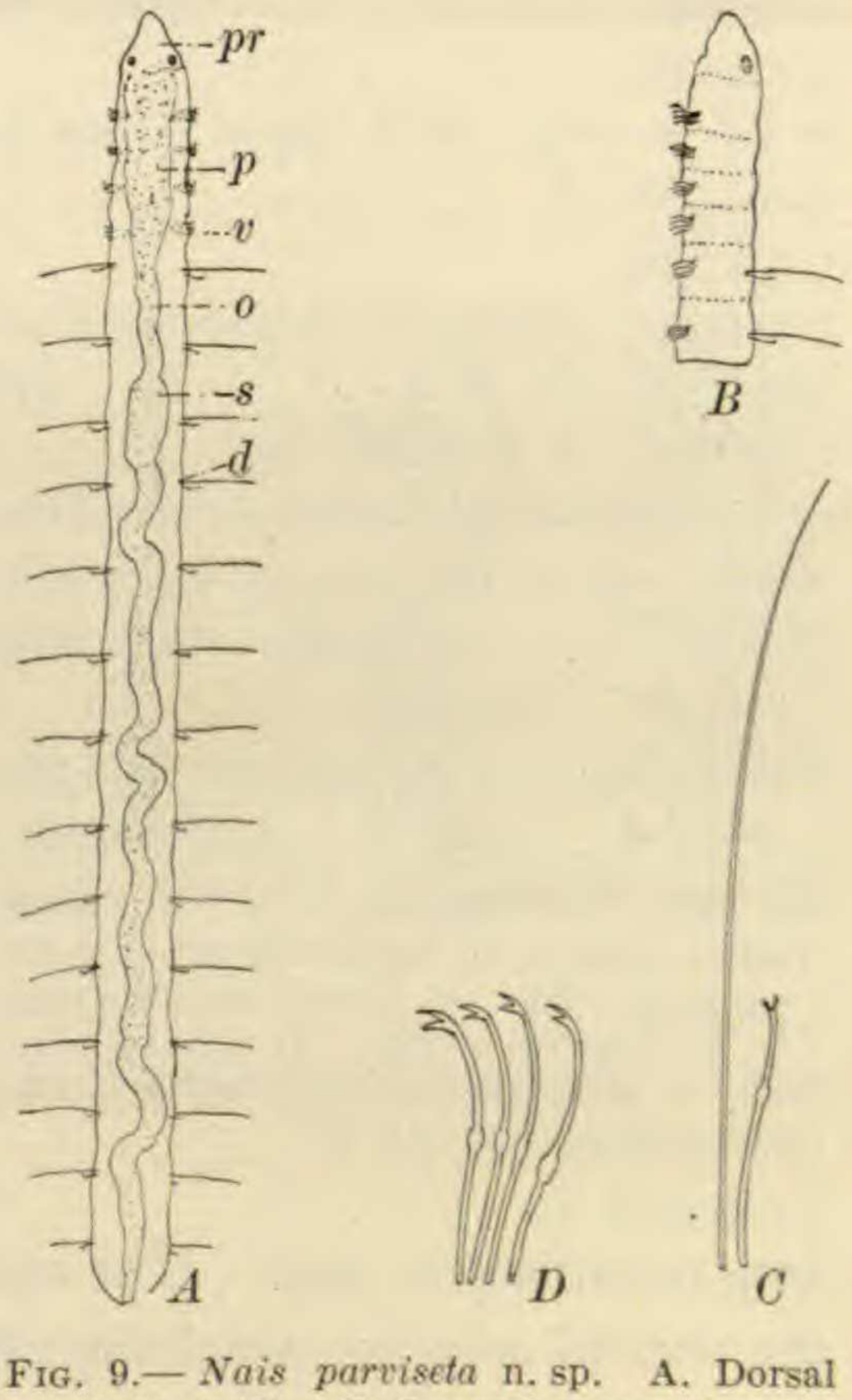

FIG. 9.— *Nais parviseta* n. sp. A. Dorsal aspect (x25). B. Lateral aspect, first six segments (x25). C. Dorsal bundle of setæ (x250). D. Ventral bundle of setæ, 4th segment (x250). For abbreviations see Fig. 1.

Cedar Point, Sandusky, Ohio.

A very few specimens of this form were observed. Budding was noted in nearly all of the individuals examined. The characteristic differentiation of the teeth on the ventral setæ appears to be of considerable specific importance.

Nais tenuidentis n. sp.

Prostomium blunt. Eyes absent. Digestive tract not differentiated into esophagus or stomach, covered with many brownish globules. Dorsal bundle beginning on 6th segment, composed of 1 capilliform, the length (180 μ) of which is approximately one half the diameter of the body, and 1 short (60 μ) biuncinate seta possessing equally developed teeth and provided with a nodulus. Ventral bundle consisting of 4 (3 in several anterior bundles) deeply bifid setæ, both teeth being exceedingly long and slender, the upper measuring 20 μ and the lower 14 μ from the base of the cleft area. Length 3 to 3.5 mm. Number of segments in an individual approximately 20. Budding observed.

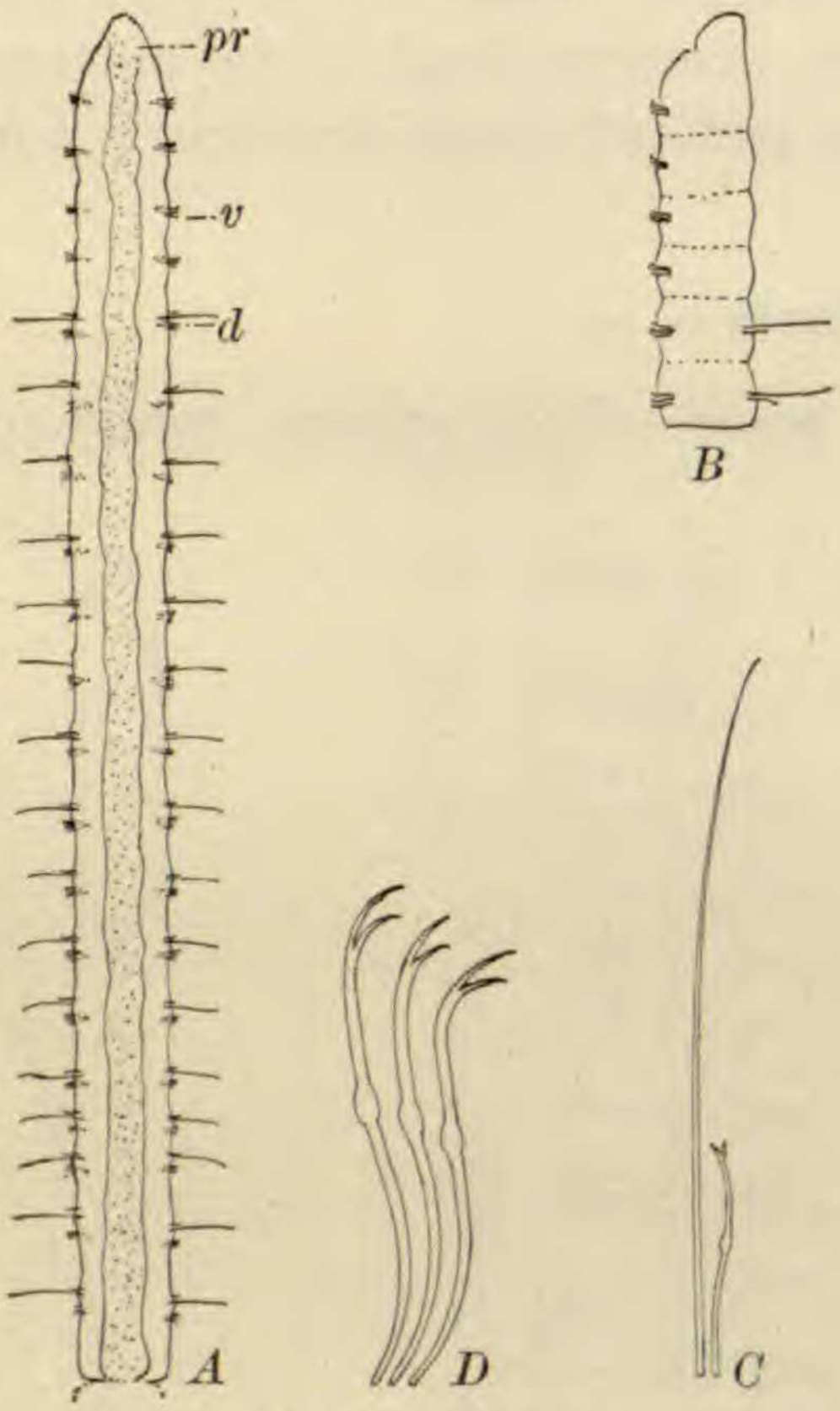

FIG. 10.— *Nais tenuidentis* n. sp. A. Dorsal aspect (x25). B. Lateral aspect, first six segments (x25). C. Dorsal bundle of setæ of 7th segment (x250). D. Ventral bundle of setæ, 2d segment (x250). For abbreviations see Fig. 1.

Cedar Point, Sandusky, Ohio.

Only two specimens of *N. tenuidentis* were found, budding occurring in each. The extremely long and slender teeth of the ventral setæ are a striking characteristic of this species.

Genus PRISTINA Ehrenberg, 1831

Prostomium usually developed into a tentacular process. Ventral bundle composed of biuncinate setæ. Dorsal bundle beginning on the 2d segment, composed of capilliform setæ. Testes in 7th, ovaries in 8th, spermathecæ in 7th segments (description of sexual organs based on observation of one species, *P. leidyi*).

In fresh water. Europe, North America, South America, and Java; 6 species.

The species may be separated by the following table. While it is possible that a careful study of *P. æquiseta*, *P. longiseta*, and *P. flagellum*, may show that those responsible for the descriptions have overlooked the existence of the small teeth present in *P. leidyi* and *P. serpentina*, it appears evident that the species are distinct on other grounds.

A[1]. Setæ of dorsal bundle smooth.
  B[1]. Last segment not provided with finger-like processes.
    C[1]. Dorsal setæ of 3d segment not decidedly longer than those of other segments; length 7 to 8 mm. . . . . *P. æquiseta.* (Europe.)
    C[2]. Dorsal setæ of 3d segment much longer than those of other segments . . . . . *P. longiseta.* (Europe.)
  B[2]. Last segment provided with 3 (2 lateral and 1 median) finger-like processes projecting posteriorly . . . . . *P. flagellum.* (N. America, S. America.)

A[2]. Setæ of dorsal bundle provided with numerous fine but distinct teeth.
  B[1]. Capilliform setæ of dorsal bundle approximately 35 μ long. Those of the 3d segment twice as long as the others . . *P. leidyi.* (N. America, S. America.)
  B[2]. Capilliform setæ of dorsal bundle approximately 300 μ long. Those of the 3d segment not longer than others.
    C[1]. Teeth of ventral setæ subequal. Number of segments approximately 14 . . . . . *P. serpentina.* (N. America.)
    C[2]. Distal teeth of ventral setæ longer than proximal teeth. Number of segments 18 to 30 . . . . . *P. proboscidea.* (S. America.)

Pristina serpentina n. sp.

Prostomium developed into a long tentacular process, usually 0.2 to 0.3 mm. in length. Eyes absent. Digestive tract with stomach in the anterior part of the 8th segment. Dorsal bundle beginning on the 6th segment, composed of 2 long (300 μ), 1 medium (100 μ) capilliform setæ, and 2 to 6 short needle-like (30 μ to 50 μ) setæ. Ventral bundle composed of 5 to 6 biuncinate (60 μ to 80 μ) setæ with subequal teeth. Length 2.2 mm. Number of segments in an individual about 15.

Cedar Point, Sandusky, Ohio.

This species of Pristina (Fig. 11) was exceedingly abundant at Cedar Point, and on first examination was apparently to be placed near *P. æquiseta* Bourne. Closer examination, however, dem-

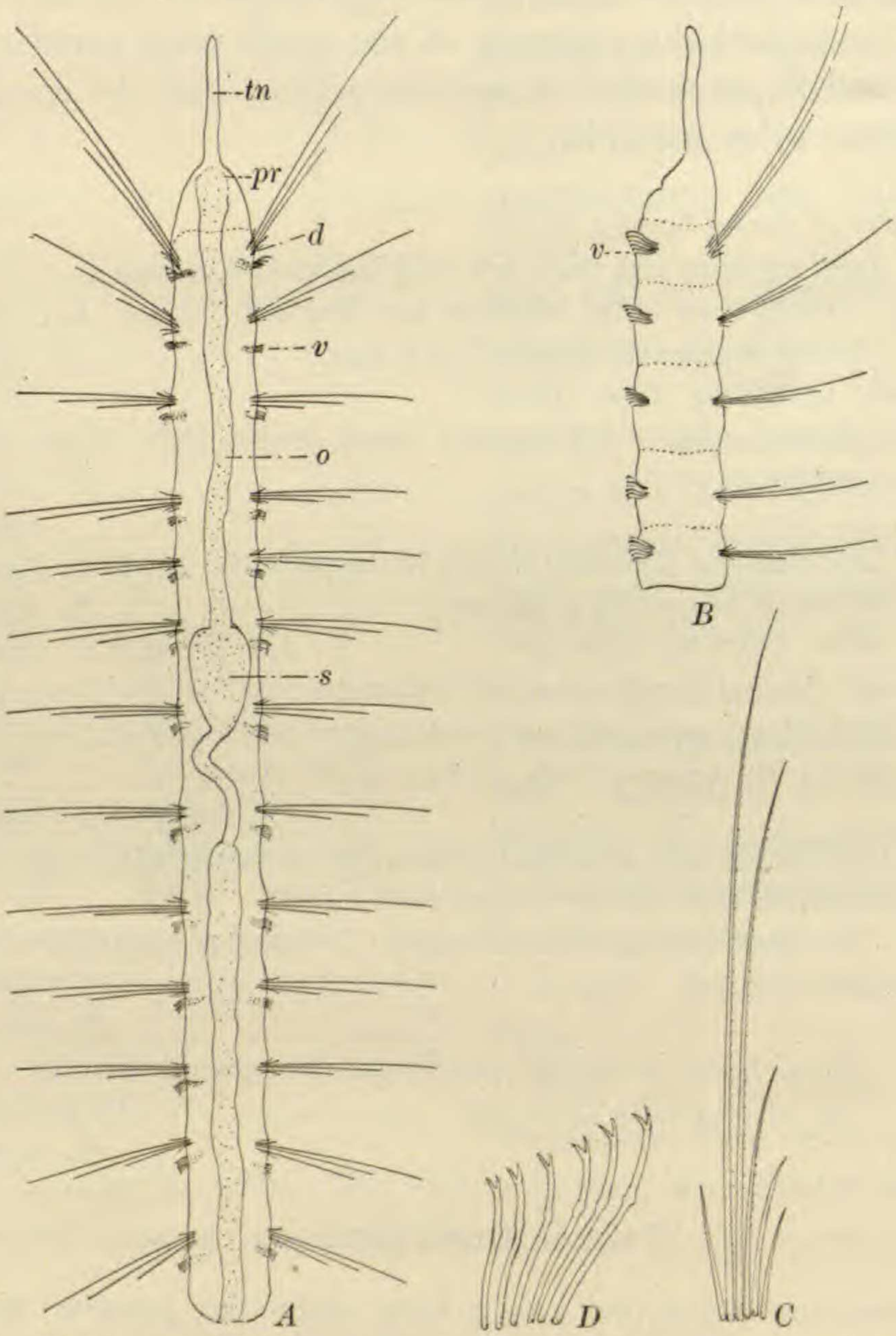

FIG. 11.— *Pristina serpentina* n. sp. A. Dorsal aspect (x50). B. Lateral aspect, first six segments (x50). C. Dorsal bundle of setæ of 7th segment (x250). D. Ventral bundle of setæ (x250). For abbreviations see Fig. 1.

onstrated the existence of fine teeth on the setæ of the dorsal bundle. The difference in the form of the distal teeth of the ventral setæ distinguishes it from *P. proboscidea* Beddard, now recognized by Michaelsen (:05) as a valid species.

Genus NAIDIUM O. Schmidt, 1847

Prostomium either rounded, pointed, or developed into a short tentacular process. Dorsal bundle beginning on the 2d segment, composed of capilliform, or needle-like, and biuncinate setæ. Ventral bundle composed of biuncinate setæ.

Fresh water. Middle Europe, East India, North America, and South America; six species.

A¹. Prostomium not developed into a tentacular process.
  B¹. Number of segments composing an individual usually 15 to 30 (32 to 40, *N. luteum*). Biuncinate setæ in dorsal bundle.
    C¹. Prostomium rounded or pointed, species small, not exceeding 5 mm. in length.
      D¹. Number of segments in an individual 20, posterior part of brain developed into 4 pronounced lobes . *N. bilobatum.* (Europe.)
      D². Number of segments in an individual 15 to 16.
        E¹. Capilliform setæ shorter than the diameter of the body. Teeth of dorsal biuncinate setæ approximate *N. uniseta.* (Europe.)
        E². Capilliform setæ longer than the diameter of the body. Teeth of dorsal biuncinate setæ remote . . *N. osborni.* (N. America.)
    C². Prostomium slightly elongate, species large, approximately 15 mm. in length . . . . . *N. luteum.* (Europe.)
  B². Number of segments in an individual 40 to 61, no biuncinate setæ in dorsal bundle . . . . . *N. dadayi.* (S. America.)
A². Prostomium developed into a short tentacular process, length of species approximating 8 mm. . . . . *N. breviseta.* (East India.)

Naidium osborni n. sp.

Prostomium moderately long, somewhat pointed. Eyes absent. Digestive system differentiated into pharynx (segments 1 to 3), esophagus (segments 4 to 7), and stomach (8th segment). Dorsal bundle of setæ beginning on the 2d segment, composed of 1 long capilliform (145 μ) and 1 short (50 μ) seta, the latter biuncinate

with subequal, remote teeth and an indistinct nodulus one third the distance from the tip. Ventral bundle composed of 4 biuncinate setæ with subequal teeth and a distinct nodulus midway between base and tip. Length 1.6 mm. Number of segments in an individual 15 to 16. Budding observed.

Cedar Point, Sandusky, Ohio.

Five species of Naidium have been described: three from central Europe, one from the East Indies, and one from South America; none, however, has been noted in North America, consequently the occurrence of a distinct species in the United States is of considerable interest. A single individual was found in the sediment of a bottle containing "reed roots" obtained at Cedar Point, Ohio, and received from Professor Osborn, September 4, 1905.

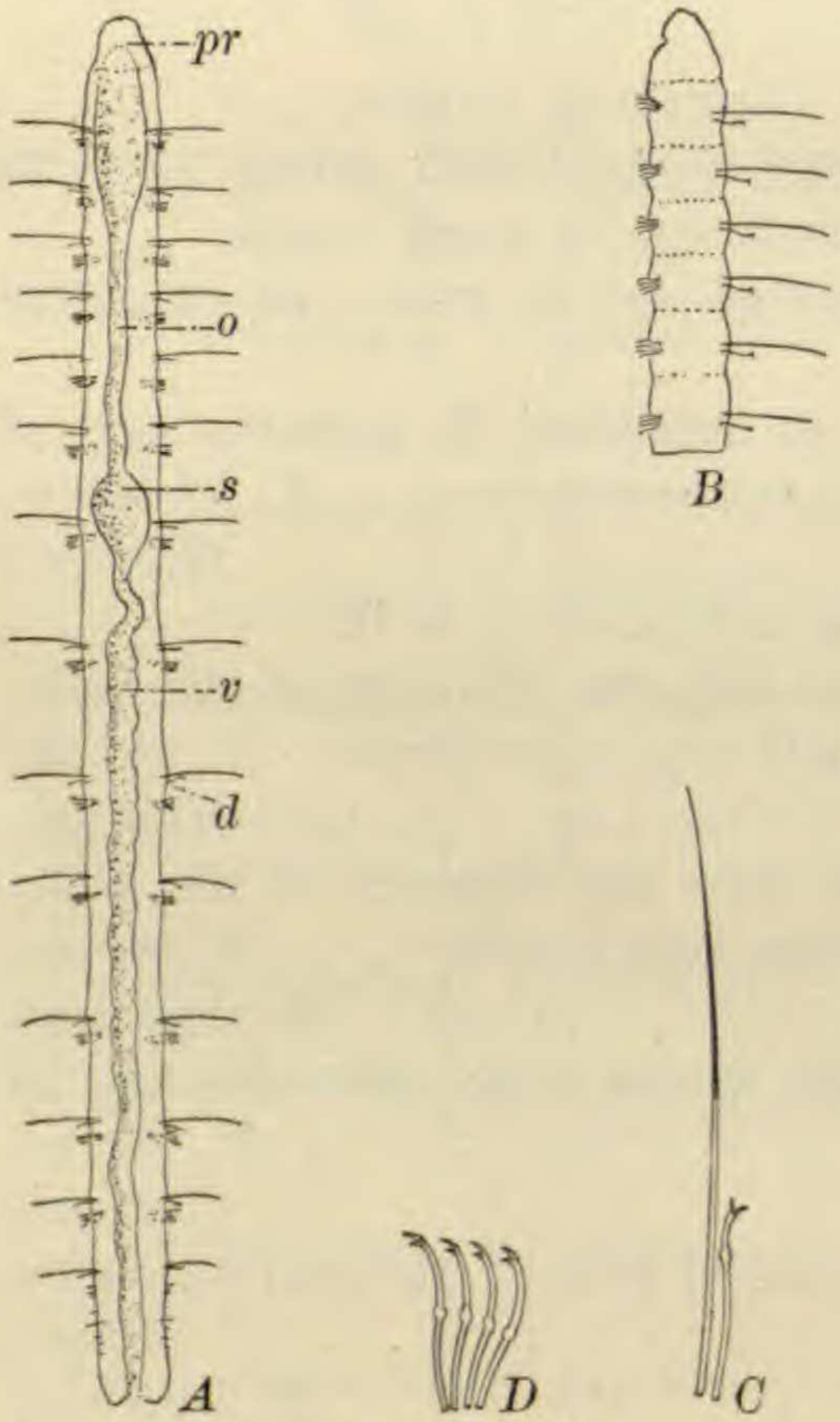

FIG. 12.— *Naidium osborni* n. sp. A. Dorsal aspect (x50). B. Lateral aspect of first six segments (x50). C. Dorsal bundle of setæ (x250). D. Ventral bundle of setæ of segment 1 (x250). For abbreviations see Fig. 1.

Schmidt (1847) founded the genus upon a single species, *N. luteum*, occurring in Europe. Beddard ('95) maintained that this species should be incorporated in the genus Pristina inasmuch as *Pristina breviseta* described by Bourne (1891) nearly bridged over the gap formerly supposed to separate the two genera. Michaelsen (:00) removed *P. breviseta* to the genus Naidium which thus consisted of two species, *N. luteum* and *N. breviseta*.

The characters which may be used for separating the two genera consist of (1) the presence as a rule of biuncinate setæ in the dorsal bundle of Naidium, while such setæ are absent in Pristina, and (2) the development of the tentacular process of the prostomium which

is either absent or extremely short in Naidium while in Pristina it is long. The absence of any tentacular process in *N. osborni* suggests that until a species is found in which the process is well developed and in which the dorsal bundles contain biuncinate setæ, the genera may be considered distinct. Further studies may show other generic characters.

I take pleasure in dedicating this species to Professor Herbert Osborn, Director of the Lake Laboratory, Sandusky, Ohio.

KENYON COLLEGE
GAMBIER, OHIO

BIBLIOGRAPHY

Only a few of the more important papers, particularly those referring to North American Naididæ, are noted.

BEDDARD, F. E.
'95. A Monograph of the Order of Oligochæta. Oxford.

BRETSCHER, K.
: 00a. Mitteilungen ueber die Oligochætenfauna der Schweiz. *Rev. Suisse Zoöl.*, vol. 8, pp. 1–44.

BRETSCHER, K.
: 00b. Südschweizerische Oligochæten. *Rev. Suisse Zoöl.*, vol. 8.

BRETSCHER, K.
: 03. Beobachtungen ueber die Oligochæten der Schweiz, VII. *Rev. Suisse Zoöl.*, pp. 1–21.

CRAGIN, F. W.
'87. First Contributions to a Knowledge of the Lower Invertebrata of Kansas. *Bull. Washb. College Laboratory*, vol. 2, no. 8, pp. 27–32.

LEIDY, J.
'50a. Description of New Genera of Vermes. *Proc. Acad. Nat. Sci. Philadelphia*, pp. 124–126.

LEIDY, J.
'50b. Descriptions of some American Annelida Abranchiata. *Journ. Acad. Nat. Sci. Philadelphia*, vol. 2, pp. 43–55.

LEIDY, J.
'52a. Helminthological Contributions. *Proc. Acad. Nat. Sci. Philadelphia*, vol. 5, pp. 226–227.

LEIDY, J.
'52b. Corrections and Additions to Former Papers on Helminthology. *Proc. Acad. Nat. Sci. Philadelphia*, vol. 5, pp. 285–287.

LEIDY, J.
'80. Notice of some Aquatic Worms of the Family Naides. *Amer. Nat.*, vol. 14, pp. 421–425.

MICHAELSEN, W.
:00. Oligochæta. *Das Tierreich*, Lief. 10. Berlin.

MICHAELSEN, W.
:03. Die geographische Verbreitung der Oligochæten. Berlin.

MICHAELSEN, W.
:05. Zur Kenntnis der Naididen. Anhang Untersuchungen ueber die Susswasser-mikrofauna Paraguays. *Zoölogica*, vol. 44, pp. 350–361.

MINOR.
'63. Upon Natural and Artificial Selection in some Chætopod Annelida. *Amer. Journ. Sci.*, ser. 2, vol. 35, p. 35–43.

REIGHARD, J.
'85. On the Anatomy and Histology of *Aulophorus vagus*. *Proc. Amer. Acad. Arts and Sci.*, vol. 20, pp. 88–106.

SMITH, FRANK.
'96. Notes of Species of North American Oligochæta. *Bull. Ill. State Lab. Nat. Hist.*, vol. 4, pp. 396–411.

SMITH, FRANK.
:00. Notes on Species of North American Oligochæta. *Bull. Ill. State Lab. Nat. Hist.*, vol. 5, pp. 441–458.

VEJDOVSKY, F.
'84. System und Morphologie der Oligochæten. Prag.

MECHANISM OF THE ODONTOPHORAL APPARATUS IN *SYCOTYPUS CANALICULATUS*

J. C. HERRICK

Introduction

This paper gives the results of some four or five weeks spent in dissecting and experimenting on the odontophoral apparatus in the large familiar whelk or winkle, *Sycotypus canaliculatus* (Linn.).[1] The work was done at the Marine Laboratory at Wood's Hole, Mass., during the summer of 1905. I desire to express here my thanks to the direction of the laboratory for the material furnished and privileges extended, especially to Dr. G. A. Drew to whom I am indebted for advice and encouragement.

The object of the paper is to show the *modus operandi* of the whole odontophoral mechanism as found in the form selected, and also, incidentally to describe the nervous supply of the muscles that control the mechanism. To this end the anatomy of the parts has to be described in some detail, but it is hoped that the figures which accompany the text may serve to give some substance to the descriptions.

Sycotypus because of its large size offers excellent material for such a study. The whole apparatus can be studied with the naked eye, no dissecting lens being necessary except for examining the teeth. Besides, since this animal is a great pest to the oysterman and clam digger on account of its depredations upon the beds, it is of some interest — aside from the purely scientific — to know more intimately how this gastropod accomplishes its destructive work of boring through the shells of oysters and clams, and rasping out their soft contents by means of its file-like "tongue."

[1] Synonymy (Verrill): Murex, Pyrula, Busycon, Fulgur.

METHOD

The method followed was that of gross dissection, combined with that of stimulation by the induced electric current, of the muscles and nerves concerned. The animals were freed from their shells by means of a hatchet, chipping away the shell along the line of the canal, and finally twisting the animal out; and then left for twelve hours or more in a mixture of waste alcohol and turpentine. This treatment[1] causes the animal to put forth its proboscis usually in full extension, and does not really kill it, though, of course, causing deep narcosis. In this condition the various muscles (or nerves) can be dissected out, stimulated, and their action studied.

HISTORICAL

Huxley, in 1853, was the first to study the mechanism of the buccal or odontophoral apparatus in a number of forms. He observed it in action in the transparent heteropod, Firoloides, and from what he saw was led to believe that Cuvier had failed to grasp the mode of operation of the same apparatus which he had described in Buccinum. Cuvier, to quote Huxley, "considered the tongue-plate [radula] to be passive, and that its movements depended upon the protraction, retraction, divergence, or approximation of the cartilages." According to Huxley, Middendorf also, in his elaborate monograph upon Chiton, in which he gives a very careful and detailed description of the buccal apparatus, "fails in rendering its action clear." The radula "acts as a sort of elastic file pushed from behind [!] by a special muscle, the 'curvator radulæ,' and supported and steadied by the 'folliculi motores' [buccal cartilages]."

It will be well to quote in full Huxley's own explanation of the mode of operation of the apparatus, as I deem it the correct one, though, as we shall see, denied subsequently by his pupil, Professor Geddes and others: "I have already described the manner in which the apparatus may be seen working in Firoloides and Atlanta and I propose now to demonstrate that from the anatomical arrange-

[1] Due to Mr. G. M. Gray, Curator, I believe.

ments the 'tongue' has the same chainsaw-like mode of operation throughout the Cephalopoda and Gasteropoda. Perhaps Patella may be taken as the most convenient illustration, since the organ is here very large [however, not nearly so large as in Sycotypus], and its parts are distinct and well developed." After describing the apparatus in Patella, he says: "It is clear that the action of the intrinsic muscular bands (having the insertions described) must be to cause the elastic plate [radular membrane], and with it the 'dentigerous plate' [radula], to traverse over the ends of the cartilages, just like a band over its pulley, the cartilages themselves being entirely passive in the matter. The extrinsic bands, again, must serve to protract the whole mass and thrust it more or less firmly against the object to be acted upon.

"I have examined Buccinum, Fisurella, Doris, Aplysia, Bullæa, Helix, Onchidium, Cypræa, Pteroceras, Sigaretus and Vermetus, and in all I have found a structure essentially similar to that here described . . . .

"This pulley-like structure of the tongue appears to me to be very characteristic of the portion of the molluscous type here considered [cephalous], and indeed to be peculiar to it" (Huxley, '53, p. 58, ff.).

Lacaze-Duthiers ('56) in his study on Dentalium describes the odontophoral apparatus fully and takes up the question of its mechanism. He concludes ('56, p. 258) that "the cartilage executes movements and communicates them secondarily to the dental apparatus."

In 1879, Geddes, at the suggestion of Huxley, took up the study of the odontophoral apparatus again, but arrived at just the opposite conclusion to that of the latter. He says in regard to Patella that "a slight sliding of the radula over the apex of the cartilages" may take place; but for Buccinum: "Little of that sliding movement over the apex of the cartilages which we saw in Patella can here take place, owing partly to the weakness and curvature in two planes of the cartilages, partly to the sharpness of their apex, eminently unfitting it for a pulley-block, partly to the slight fixed flexure of the radula, and its wants of pliability, and largely also to the attachment of the infraradular membrane to the sides of the mouth all round, which thus fixes the radula very steadily over

the cartilages. Some little yielding *may* take place; but it must be evident, from the above considerations, that the movements of the radula are similar to, and dependent upon, that licking action impressed upon the buccal cartilages in the way we have seen....

"Thus the explanation here put forward has something more in common with that of Cuvier....than with the later theory proposed by Professor Huxley....

"In the transparent bodies of some Heteropoda, Prof. Huxley describes a chain-saw movement; so, if the framework remains quite stationary, I can only suggest that the sliding of the radula over its support, which we saw as a secondary factor in the Limpet, though impossible in the Cuttlefish and highly improbable in the Whelk, may in these animals have acquired greater importance."

Tryon ('81) in his *Manual of Conchology* (continued by Pilsbry) gives nothing as to the mechanism of the odontophoral apparatus.

Wegmann ('84) describes the odontophoral apparatus in Haliotis and as regards the mechanism says ('84, p. 304): —

"No muscle is inserted upon the radula properly speaking; this organ is borne by the elastic membrane [radular membrane], with which it forms one body in its movements. The latter slides over the cartilages, drawn as it is by two pairs of protractor muscles and by numerous retractor bundles. Besides, the cartilages can be brought together or separated, increase and diminish the space between them. The elastic membrane is deeply influenced by these displacements and its own movements are thus complicated."

Boutan ('86) in his paper on Fissurella gives a brief description of the muscles of the odontophoral apparatus, but does not dwell upon the mechanism except to emphasize the importance of the blood sinuses in the proboscis. These during protrusion of the proboscis become filled with blood and produce turgidity of the organ, in fact, the protrusion is in part due to this turgid condition of the proboscis.

Bouvier ('87), while he gives a minute description of the nervous system of Buccinum and of many other Prosobranchs in his elaborate paper, does not describe the odontophoral apparatus at all fully.

Gibson ('87) describes the odontophoral apparatus of Patella but has nothing to say upon the subject of its mechanism.